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Public Perceptions of Risk to Forest Biodiversity†

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This study examines the perceived risks to forest biodiversity and perceived effectiveness of biodiversity conservation strategies among the general public. It tests the hypotheses that perceived risk to forest biodiversity is influenced by cognitive factors (value orientation and knowledge) and social-cultural factors (such as gender and environmental membership) and that risk perceptions influence other cognitive constructs such as support for natural resource policy and management. Data were collected from a sample of the general public ($n = 596$) in British Columbia, Canada by mail survey in 2001. Results show that insects and disease were perceived as the greatest risk. Educating the public and industry about biodiversity issues was perceived as a more effective conservation strategy than restricting human uses of the forest. Value orientation was a better predictor of perceptions of risk and perceived effectiveness of conservation strategies than knowledge indicators or social-cultural variables. Examining the indirect effects of social-cultural variables, however, revealed that value orientation may amplify the effect of these variables and suggests that alternative paths of influence should be included. Perceived risk showed an inconsistent association with perceived effectiveness of conservation strategies.

KEY WORDS: Biodiversity; ecological risk; forest management; risk perception

1. INTRODUCTION

Much of the social science literature on biodiversity has focused on assigning value to biological resources including both use (e.g., pharmaceuticals) and nonuse (e.g., willingness to pay for biodiversity conservation) values.[1] Although these have contributed substantially to understanding the economics of biodiversity conservation and the tradeoffs associated with conservation options, there remains a need to understand public perceptions of risk associated with biodiversity conservation and the factors that influence these perceptions. A review of the literature on perceptions of risk did not reveal any studies specific to biodiversity. However, a complementary literature has emerged on perceptions of ecological risks (i.e., threats to the health and productivity of species and ecosystems).[2]

Studies of ecological risk include perceptions of threats from a wide range of human activities such as development, pollution, climate change, and industrial activity. McDaniels *et al.*,[2] for example, showed that university students rated nuclear war, loss of animal and plant species, loss of habitats, ozone depletion, and deforestation among the greatest risks to natural environments. Similarly, pollution (acid rain, automobile emissions, ozone depletion, disposal of waste products), climate change, and forest industry-related hazards were rated as the greatest hazards to water environments by the lay public.[3] In contrast, natural hazards (such as earthquakes, floods, and drought) were perceived as posing only low to moderate risk to ecosystems.[2]

Different populations assess risk differently. For example, the lay public and experts have some

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similarities and differences in assessments of several potential threats to ecosystems.[3–5] Experts and the public perceived global climate change as less avoidable and more acceptable than other hazards. The experts, however, perceived climate change as having lower impacts, being less avoidable and understandable, and more acceptable than the public. [5]

Although studies have quantified perception of risk of various hazards to ecosystems, the factors that influence perceptions of ecological risk are not well understood and have been limited to examining the influence of demographics, political factors, and value orientation.[5,6] Additionally, the literature has rarely examined the consequences of risk perceptions of ecological systems. A few studies have reported the influence of environmental risk perception on behavior. For example, risk perception was one of several predictors and contributed substantially to the explained variance of behavioral intentions related to climate change.[7] A more substantial literature on natural hazards such as earthquakes, floods, and wildfires suggests that perceived risk has no clear influence on behaviors aimed at abating damage or reducing risk.[8,9] The influence of perception of risk on preferences for natural resource policy and management strategies is generally lacking from the literature. However, McDaniels *et al.*[4] found that ecological risk perception was highly predictive of supporting stricter regulations to industrial and development activities that threaten water environments. Similarly, perceived risk from wildfire has been associated with preferences for management strategies. The perception of high risk to personal property from wildland fire, for example, was one factor associated with the preference for strategies aimed at putting fires out whereas low perceived risk was associated with letting fires burn.[10]

This study examines perceived risk to a specific hazard domain of ecological risk (i.e., biodiversity) and perceived effectiveness of biodiversity conservation strategies among the general population of the Province of British Columbia (BC), Canada. It tests the hypothesis that cognitive structures (environmental value orientation and knowledge) and social-cultural factors (such as gender and membership in environmental organizations) influence general perceptions of risk to biodiversity in forested environments. It extends the current literature by testing the hypothesis that perception of risk to biodiversity influences perceived effectiveness of biodiversity conservation strategies. The specific objectives were to:

1. Examine risk perception of threats to forest biodiversity and perceived effectiveness of biodiversity conservation strategies among the general population of BC.
2. Examine the underlying factors influencing risk perception associated with threats to forest biodiversity among the general population of BC.
3. Examine the influence of risk perception and other underlying factors on perceived effectiveness of biodiversity conservation strategies among the general population of BC.

2. DIMENSIONS OF ECOLOGICAL RISK PERCEPTION

Psychometric analysis has revealed that risk perception is a multidimensional construct that includes an assessment of both probability and consequences of impacts.[11] Based on the psychometric paradigm characterizing perceptions of health risk from technologies, several dimensions of ecological risk have been identified and used to quantify and map ecological risk perception.[2–4] These include dimensions of ecological impact (e.g., species loss and impacts on humans), human benefits (e.g., equity of costs and benefits), controllability (e.g., ability to control impacts), and knowledge of impacts (e.g., alternative events or practices). These dimensions underscore the complexity of risk perception and provide a framework for the cognitive characterization of ecological risk. Understanding the underlying dimensions of risk can be helpful in developing communication strategies, in understanding diversity in risk perception, and in influencing behavior and designing incentives aimed at mitigating risk.[2,3]

A dimension of general risk (an assessment of how risky in general a hazard is in terms of its impacts on the health and productivity of natural environments) has also been used to characterize ecological risk perception. This dimension, however, does not distinguish between probability and consequences of impacts and correlates highly with other risk dimensions (e.g., ecological impacts and human benefits),[4] suggesting that a general risk dimension encompasses many characteristics of perceived risk. It is the general risk dimension, rather than a multidimensional framework, which largely has been used in multivariate analyses of factors influencing perception and in comparing risk perceptions of experts and laypeople.[4,5]

3. CORRELATES OF ECOLOGICAL RISK PERCEPTION AND NATURAL RESOURCE POLICY PREFERENCES

3.1. Cognitive Factors

Drawing upon the social-psychological literature, O'Connor *et al.*[7] postulated that environmental cognitions are the basis of environmental risk perceptions. These cognitions are represented by general attitudes, specific beliefs, and environmental knowledge. General attitudes are non-issue-specific cognitive orientations[7] that form the basis for specific beliefs (such as risk perception) and behaviors.[12,13] General attitudes toward the environment are commonly referred to as value orientation and are frequently categorized into two contrasting belief systems labeled anthropocentric and biocentric (or ecocentric).[14–16] An anthropocentric orientation reflects a utilitarian view of nature whereby natural resources are defined in terms of satisfying human wants and needs and their contribution to economic prosperity and human well-being. A biocentric orientation reflects a broader range of values including, for example, esthetic, spiritual, and passive use values.[16] Although human uses and benefits are also included, nature is viewed as having inherent worth; a right to exist for its own sake regardless of its usefulness to humans. Other species and ecosystem processes may take precedence over human needs in management decisions. Generally, value orientation is expressed as a combination of biocentric and anthropocentric orientation and people are seldom strictly classified as one or the other.[17]

Environmental value orientation has been found to be instrumental in people's assessment and response to environmental risk[6,7] and preferences for natural resource management.[16] For example, biocentric-oriented values have been associated with higher levels of perceived risk and support for protection-oriented management. Thus it is hypothesized that a biocentric orientation will be associated with higher risk ratings to forest biodiversity and greater perceived effectiveness of conservation strategies aimed at reducing human use. In contrast, an anthropocentric orientation will be associated with lower risk ratings and lower perceived effectiveness of reducing human use.

Cognition, represented by knowledge of risk domains, is central to much risk perception research. Indeed, conflict over environmental hazards has been attributed to an ignorant, irrational public uninformed of technologies and risk analysis.[18] In contrast, experts are portrayed as the rational players, possessing specialized knowledge that makes them better informed of the potential risks and whose risk judgments are to be trusted. Although the effect of knowledge on perception of ecological risk has not been examined explicitly, experts tend to judge ecological risks differently than the lay public.[3,4] For example, experts judged construction of logging roads as more of a risk to water environments and more in need of regulation than did the public. The public perceived pesticide use as more of a risk than did the experts. Given this apparent influence of knowledge, it is hypothesized that knowledge of relevant biodiversity policies and issues will influence both risk perception and perceived effectiveness of biodiversity conservation strategies.

3.2. Social-Cultural Influences

Social-cultural factors are known to interact with individual cognitions in risk assessment. Gender, age, education, income, and other demographics have been found to influence risk perception. One of the most consistent findings in risk perception research is that women tend to be more concerned about hazards than men.[19–21] Differences in perceptions between women and men have been attributed to social roles. Women fulfill the roles of nurturers and caregivers whereas men are the creators, controllers, and economic benefactors of risk technologies. Although women generally perceive greater risk than men, Lazio *et al.*[5] found that men perceived greater overall riskiness to ecosystems. Older individuals, whites, and people with higher levels of education and income tend to be less concerned about hazards.[20–22] These differences have been attributed to these groups being less exposed to risk, having the financial means to prevent exposure to risks, and having a better understanding of the scientific nature of risks. Although the literature is less clear on the effect of social-cultural factors on natural resource management preferences, many studies suggest that women, younger individuals, and people with higher levels of education are more concerned about the environment and are more supportive of protection-oriented policies.[7,23,24] Based on these findings, it is hypothesized that women, younger individuals, and people with low levels of education will perceive greater risk to forest biodiversity and perceive greater effectiveness in conservation strategies aimed at reducing human use.

Social groups can influence member responses to risk issues by imparting cultural meanings and

amplifying or attenuating individual judgments of risk.[25] Individuals in different cultural contexts define the world differently, have different belief systems, norms of behavior, and judgments of what poses a risk.[18] Cultural influences structure the mindset of individuals such that members of organizations or social groups adopt organizational values, beliefs, and norms. For example, environmental organizations play a major role in the development and transmission of alternative environmental views.[23,26] Similarly, individuals whose work focuses on natural resource management and who must work to achieve organizational goals are expected to view risk to biodiversity in a manner consistent with organizational values and their professional interests.[18] Thus it is hypothesized that subscribing to environmental organizations or having a household member employed in a natural resource sector will influence perceived risk and perceived effectiveness of biodiversity conservation strategies.

4. METHODS

4.1. The Survey

A sample of the general public in the Province of BC, Canada was obtained by telephone solicitation through a stratified random selection of listed telephone numbers. The sample was stratified to ensure adequate sample sizes to compare results from three geographical areas: 30% of the sample was from the Robson Valley area, 30% from the Prince George area, and 40% from the remainder of the province. The Robson Valley sample included the communities of Valemont, McBride, Tete Jaune, Dunster, Crescent Spur, and surrounding areas. A total of 2,260 people, 18 years or older, were contacted and asked to participate in a mail survey. Of these, 1,125 agreed to participate (49.8%); 1,052 were selected at random for the mail survey.

The 14-page questionnaire consisted of measures of knowledge pertaining to biodiversity and biodiversity issues, perceptions of risks to biodiversity in BC, perceptions of the effectiveness of strategies to conserve biodiversity, who should be responsible for biodiversity conservation, and a choice experiment for an analysis of tradeoffs associated with biodiversity conservation.[27] To ensure that participants had a common understanding of forest biodiversity, they were provided with the following definition: "In general, biodiversity can be described as the variety of living things. Forest biodiversity issues involve the variety and type of living things in the forest." The precise wording for each question is available from the author.

Questionnaires were mailed in December 2001. Seven days later a reminder postcard was sent and 6 weeks after the initial mailing a second questionnaire was sent to those who had not responded. Adjusting for invalid addresses, the response rate on the mail survey was 61% ($n = 596$).

The stratification of the sample resulted in an overrepresentation of respondents from the Robson Valley and Prince George relative to their representation in the general population of BC. To ensure that the results were reflective of the general provincial population, the results were weighted proportional to the expected observations from a simple random sample.

4.2. Variables

4.2.1. Value Orientation

Biocentric and anthropocentric orientations toward forests were measured using 16 statements rated on a 5-point scale ranging from strongly disagree to strongly agree.[12,25] Principal factor analysis identified two factors corresponding to a biocentric and anthropocentric orientation. Reliability analysis indicated Cronbach's alphas of 0.82 for the biocentric factor and 0.75 for the anthropocentric factor. Two indices of value orientation were created for each respondent by summing the responses for items that loaded on the corresponding factors.

4.2.2. Knowledge

Knowledge was measured using self-rated familiarity with the term biodiversity and familiarity with biodiversity-related issues in BC. Respondents' ratings of how familiar they were with the term biodiversity were based on four categories ranging from completely unfamiliar (never heard of it) to completely familiar (use the term often). Familiarity with biodiversity issues was measured based on respondents answering 11 statements as true, false, or not sure. A composite knowledge score was calculated by summing the number of correct responses.

4.2.3. Social-Cultural

Belonging to an environmental organization and dependence of a household member on a natural

resource sector (forestry, mining, oil and gas industries, or a natural resource agency) for their economic livelihood were included as cultural variables. Membership in an environmental organization and dependence on a natural resource sector were treated as dummy variables with 0 = no and 1= yes.

Social variables included age, sex, and education. Age was measured in years. Sex was treated as a dummy variable with women = 1 and men = 0. Education was measured in eight categories. The categories were converted to years of education based on the midpoints of the categories. The midpoints ranged from 5 (Grade 9 or less) to 18 years (a graduate university degree).

4.2.4. Risk to Forest Biodiversity

General risk perception was assessed by respondents rating 15 hazards in terms of their long-term threat to forest biodiversity in BC on a 5-point scale ranging from not a threat at all to a great threat, with 3 = no opinion. To reduce the 15 items to a manageable number of variables for regression analyses and to reduce collinearity, the items that were rated as a threat ($M > 3.0$) were factor analyzed using principal components. In the regression analyses, indices of risk were created for each factor by summing the responses of the items that loaded on each.

4.2.5. Effectiveness of Conservation Strategies

Perceptions of the effectiveness of natural resource policy and management options in maintaining or enhancing forest biodiversity were rated on a 4-point scale ranging from not at all effective to completely effective. The options included establishing more restrictive regulations and legislation for industrial use of the forest, increasing the amount of protected area, educating the public and industry about biodiversity issues, and closing roads to restrict access in some wilderness areas.

4.3. Analyses

Paired comparison *t* tests were used to examine differences in ratings of perceived risks and effectiveness of biodiversity conservation strategies. Ordinary least squares regression was used to observe the contributions of the independent variables to risk perception and perceived effectiveness of conservation options. Fig. 1 shows the hypothesized causal relationships. First, perceived risks to biodiversity were regressed on the social-cultural and cognition (value orientation and knowledge) variables. Second, the perceived effectiveness of conservation options was regressed on the social-cultural and cognition (value orientation, knowledge, and risk perception) variables. Finally, to provide an analysis of the indirect effects (via value orientation), value orientation was regressed on the social-cultural variables. Correlation coefficients among the independent variables did not exceed 0.43; therefore, collinearity was not of concern.[26] Statistical analyses were performed using SAS® version 8.2 software.

5. RESULTS

5.1. Perception of Risk

Table I presents the means of perceived risk to forest biodiversity in BC. All forestry-related items, mining, oil and gas activities, climate change, the conversion of forested land to urbanization and agriculture, forest fires, and insects and disease were rated as a threat ($M > 3.0$). Grazing on forested lands,

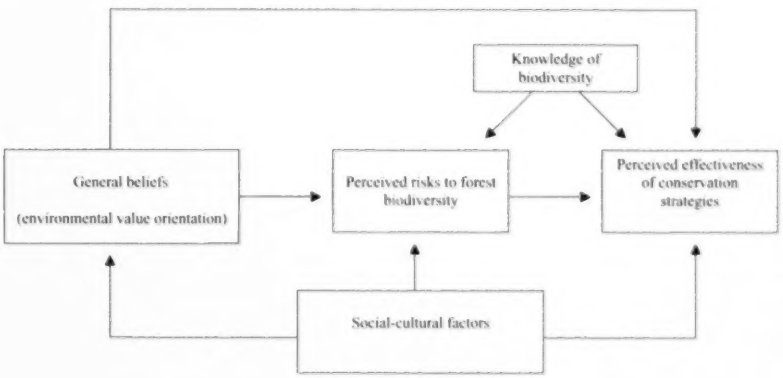
Knowledge of biodiversity
General beliefs (environmental value orientation)
Perceived risks to forest biodiversity
Perceived effectiveness of conservation strategies
Social-cultural factors

Fig. 1. Representation of hypothesized relationships.

	Mean[a]	Standard Deviation	Sample Size
Insects and diseases	4.20	1.09	590
The amount of trees being logged	4.04	1.18	588
Loss of forest land for urbanization (i.e., housing development)	3.94	1.19	592
Climate change or global warming	3.92	1.11	587
Loss of old growth forests	3.90	1.22	587
The methods used to log trees (logging practices)	3.76	1.17	592
Loss of forest land to agriculture	3.41	1.31	590
Oil and gas exploration and pipelines	3.40	1.16	590
The amount of forested land in the province allocated for timber harvesting	3.33	1.24	587
Mining	3.33	1.25	592
Forest fires	3.32	1.45	589
Genetic modification of tree species	3.16	1.21	585
Big game hunting	2.84	1.33	591
Grazing on forest lands	2.74	1.16	592
The amount of recreation use occurring in the forest	2.65	1.16	591

[a]Rated on a scale of 1 to 5, where 1 = not a threat at all and 5 = a great threat.

Table I. Distribution of Perceived Risks to Forest Biodiversity Among Residents of British Columbia

big game hunting, and recreational use of the forest were not rated as threats ($M < 3.0$). Insects and disease was perceived as the greatest risk to biodiversity ($M = 4.20$, $t = 2.40$, $df = 585$, $p = 0.017$), followed by the number of trees being logged and urbanization ($M = 4.04$, $t = 1.87$, $df = 587$, $p = 0.0619$).

Factor analysis of the risk items identified four factors that correspond to forestry activities, other industrial activities, land conversion, and natural disturbance (Table II). This solution accounted for 65% of the variance. Three of the factors had reliabilities ranging from 0.70 to 0.79. However, the factor labeled "natural disturbance" had a low reliability of 0.43. This can be attributed to the small number of items on the factor and high cross-loadings.

Table II. Factor Analysis of Perceived Risks to Forest Biodiversity

	Factor 1 (Forestry Activity)	Factor 2 (Other Industrial Activity)	Factor 3 (Land Conversion)	Factor 4 (Natural Disturbance)
The amount of trees being logged	0.81			
The amount of forested land in the province allocated for timber harvesting	0.81			
The methods used to log trees (logging practices)	0.77			
Loss of old growth forests	0.73			
Genetic modification of tree species	0.41			
Mining		0.82		
Oil and gas exploration and pipelines		0.73		
Climate change or global warming		0.58		
Loss of forest land to agriculture			0.77	
Loss of forest land to urbanization (i.e., housing development)			0.64	
Forest fires				0.87
Insects and diseases				0.44
Explained variance	0.36	0.11	0.10	0.08
Cronbach's α	0.79	0.70	0.77	0.43

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Table III. Standardized Regression Estimates (β) of Variables Associated with Perceived Risks to Forest Biodiversity

	Perceived Risks			
Independent Variables	Forestry Activity	Other Industrial Activity	Land Conversion	Natural Disturbance
Value orientation				
Biocentric	0.418*	0.232*	0.253*	0.156*
Anthropocentric	−0.367*	−0.232*	−0.165*	0.132**
Knowledge				
Self-rated familiarity	−0.038	−0.066	0.009	−0.198*
Knowledge score	0.038	0.044	0.115**	−0.105**
Social-cultural				
Environmental member	−0.009	−0.062	0.041	−0.326*
Resource dependence	−0.097**	−0.080	−0.009	−0.071
Age	0.040	−0.051	−0.096***	−0.006
Sex	0.053	0.092***	0.137**	0.109**
Education	0.127*	0.038	0.093*	−0.149*
n	503	513	515	511
F value	59.37*	16.15*	16.77*	27.52*
Adjusted R^2	0.511	0.210	0.216	0.319

*$p < 0.001$.
**$p < 0.01$.
***$p < 0.05$.

To examine influences on risk perceptions, each risk factor was regressed on value orientation, knowledge indicators, and social-cultural variables (Table III). Value orientation was the only variable associated with all four factors and, with the exception of natural disturbance, had stronger associations than knowledge and the social-cultural variables. Consistent with the hypothesis, a biocentric orientation was associated with higher risk ratings and an anthropocentric orientation was generally associated with lower risk ratings.

The knowledge indicators, significant on two of the factors, showed inconsistent results. Higher levels of knowledge were associated with lower risk ratings on natural disturbance but higher risk ratings on land conversion.

Sex was the only social-cultural variable that showed a consistent relationship. Results support the hypothesis that women tend to perceive greater risk than men. These models explained between 21% and 51% of the variance in perceived risk.

5.2. Conservation Strategies

Educating the public and industry about biodiversity issues was rated as the most effective conservation strategy ($M = 3.06$, $t = 8.11$, $df = 555$, $p < 0.0001$), followed by establishing more restrictive regulations and legislation for industrial use of the forest ($M = 2.76$), and establishing more protected area ($M = 2.67$, $t = 2.54$, $df = 554$, $p = 0.0114$). Restricting access by closing roads in some wilderness areas was perceived as the least effective strategy ($M = 2.36$, $t = 7.73$, $df = 555$, $p < 0.0001$).

An examination of the factors influencing perceived effectiveness of conservation strategies (Table IV) shows that only value orientation was associated with all of the strategies. Consistent with the hypothesis, individuals with higher biocentric scores perceived greater effectiveness from strategies that put restrictions on human use of the forest (i.e., regulating industry, more protected area, and restricting access). In contrast, individuals with higher anthropocentric scores perceived less effectiveness in restricting human use.

Self-rated familiarity with the term biodiversity had a negative association with perceived effectiveness of educating the public and industry and establishing stricter regulations for industry but it had a positive association with restricting access to wilderness. Knowledge of biodiversity issues influenced only one option: it had a negative influence on educating the public and industry.

The influence of perceived risk does not show a clear pattern. For example, risk from forestry activity had relatively strong, positive effects on regulating industry and establishing more protected area. However, perceived risk from other industrial activities

	Conservation Strategies			
	Educate	Regulate	Protect	Restrict Access
Value orientation				
Biocentric	0.359*	0.302*	0.289*	0.166**
Anthropocentric	0.212*	−0.105***	−0.109***	−0.144**
Knowledge				
Self-rated familiarity	−0.109***	−0.123**	0.015	0.181*
Knowledge score	−0.136**	0.001	−0.033	−0.035
Risk factors				
Forestry activity	−0.017	0.223*	0.296*	0.013
Other industrial activity	0.129***	0.051	−0.095***	0.165*
Land conversion	0.036	−0.051	−0.006	0.107***
Natural disturbance	−0.132**	0.012	−0.026	0.096***
Social-cultural				
Environmental member	−0.005	− 0.004	−0.012	0.101***
Resource dependence	0.086	−0.100***	−0.055	−0.019
Age	−0.098	0.041	−0.069	0.098***
Sex	−0.003	0.046	0.027	0.115**
Education	−0.062	−0.086***	−0.060	0.049
n	480	470	476	479
F value	7.85*	20.77*	16.94*	14.79*
Adjusted R^2	0.157	0.354	0.319	0.273

*$p < 0.001$.
**$p < 0.01$.
***$p < 0.05$.

Table IV. Standardized Regression Estimates (β) of Factors Associated with Perceived Effectiveness of Biodiversity Conservation Strategies

had a negative association with protected area, no association with regulating industry, and a positive association with education and restricting access.

None of the social-cultural variables were associated with perceived effectiveness of educating the public and industry or increasing the amount of protected area. However, older individuals, women, and members of environmental organizations perceived greater effectiveness in restricting access to wilderness and individuals with higher levels of education and those dependent on the natural resource sector perceived less effectiveness in greater restrictions on industry. These models explained about 16% to 35% of the variance in perceived effectiveness of conservation strategies.

5.3. Amplification of Social-Cultural Influences

Generally, the social-cultural variables did not have strong direct effects on risk perception or perceived effectiveness of conservation strategies. However, these factors may also influence risk perception and perceived effectiveness of conservation strategies indirectly through their effect on value orientation. For example, women, younger individuals, members of environmental organizations, and people with higher levels of education tend to hold stronger biocentric-oriented values[16] that in turn may influence risk perception and perceived effectiveness of conservation strategies. In this analysis, the biocentric and anthropocentric scores are treated as dependent variables and the social-cultural variables used as explanators (Table V). Consistent with previous studies on value orientation, members of environmental organizations and women had higher biocentric scores.

Table V. Standardized Regression Estimates (β) of Variables Associated with Value Orientation

	Value Orientation	
Independent Variables	Biocentric	Anthropocentric
Social-cultural		
Environmental member	0.138**	−0.053
Resource dependence	−0.118**	0.193*
Age	0.023	0.307*
Sex	0.249*	−0.204*
Education	−0.089***	−0.097***
n	551	558
F value	13.00*	26.87*
Adjusted R^2	0.098	0.189

*$p < 0.001$.
**$p < 0.01$.
***$p < 0.05$.

Table VI. Effects of Sex on Perceived Risks to Forest Biodiversity

Risk Factors	Direct Effect	Indirect Effect (Via Value Orientation)	Total Effect
Forestry activity	0	(0.249)(0.418) + (−0.204)(−0.367)	0.179
Other industrial activity	0.092	(0.249)(0.232) + (−0.204)(−0.232)	0.197
Land conversion	0.137	(0.249)(0.253) + (−0.204)(−0.165)	0.234
Natural disturbance	0.109	(0.249)(0.156) + (−0.204)(0.132)	0.121

Respondents with a household member dependent on a natural resource sector had lower biocentric and higher anthropocentric scores. Age had a positive association with the anthropocentric score and being female had a negative association. Higher levels of education were associated with lower scores on both the biocentric and anthropocentric factors. This suite of variables explained about 10% and 18% of the variance in the biocentric and anthropocentric scores, respectively.

The independent variable sex is used, as an example, to illustrate the importance of the indirect effects (via value orientation) on perceptions of risk. Indirect effects were calculated by multiplying and then summing the path coefficients: sex → value orientation → perceived risk.[29] Recall that sex did not have a direct effect on perceived risk from forestry activity (Table III). However, when the indirect effects are taken into consideration, sex has a positive influence ($\beta = 0.179$) on perceived risk from forestry activity (i.e., women have a higher level of perceived risk) (Table VI). Similarly, the effect of sex via value orientation provides an additional indirect effect of 0.105 to the direct effect of 0.092 on risk from other industrial activities and an additional 0.097 to the direct effect on risk from land conversion. The indirect effect of sex on natural disturbance is negligible.

6. DISCUSSION

The literature of ecological risk perception has focused primarily on characterizing risk associated with human activities. The current study extends this literature to a previously unexplored hazard domain (i.e., biodiversity), and includes risk associated with natural ecosystem processes (i.e., natural disturbances). It provides a more extensive analysis of explanators of ecological risk perception by including the interaction of cognitions (including knowledge of the hazard domain) with social and cultural influences and extends the ecological risk perception analysis by examining the consequences of risk perception in a multivariate context. The results indicate that insects and disease were perceived as the greatest risk to forest biodiversity. Value orientation had a greater effect on perceived risk than knowledge or social-cultural variables. Value orientation was also the most consistent predictor of perceived effectiveness of conservation strategies. Contrary to expectations, perceived risks did not show a consistent association with effectiveness of conservation strategies. Implications of the findings center on the emergence of a new perceived risk to biodiversity, implications for biodiversity conservation and natural resource policy, and the need for more complex models of risk perception.

Anthropogenic sources of ecological risk, especially industrial activity, were generally perceived as a risk to forest biodiversity. The results support Cavanagh *et al.*'s[3] findings that forestry activities are perceived as environmental risks among the public in BC and extends this threat to a new hazard domain, biodiversity. However, the current study suggests that a new perceived ecological risk may be emerging among the BC public; the threat from insects and disease. This emerging perception is probably influenced by a massive infestation of mountain pine beetle (*Dendroctonus ponderosae*) occurring in the province at the time of this study. It is estimated that the mountain pine beetle infected about 850,000 ha of public forests in west-central BC during 2001,[30] causing tremendous damage to timber supply and impacting the economy and forest-dependent communities. Indeed, the BC Ministry of Forests declared the outbreak "a forest health emergency" that "demands extraordinary measures."[31]

The finding that insects and disease was rated as the greatest risk to biodiversity has implications for biodiversity conservation. Outbreaks of mountain pine beetle are natural phenomena in mature lodgepole pine forests in BC. The current epidemic, however, is unprecedented and is compounded by forest management activities (such as fire suppression), dry summers, and warm winter weather. Although the beetle has not been implicated in losses to biodiversity, it is likely that the negative publicity generated around timber supply loss and economic

impacts of the infestation are influencing the public's perception of risk to biodiversity. In other words, the mountain pine beetle is generally perceived as having negative impacts on all aspects of forests. Individuals with higher levels of knowledge of biodiversity issues, however, perceived natural disturbance as less risky. This suggests that public education on the role of naturally occurring insects and diseases in ecosystem functions might be an effective strategy in conveying their importance to biodiversity and changing risk perceptions related to natural disturbance.

In this study, risk perception was generally a better predicator of perceived effectiveness of conservation options than the social-cultural variables. Social-cultural variables were inconsistent and weak predictors of perceived effectiveness of the conservation strategies. This may have implications for natural resource policy. For example, natural resource managers and policymakers have suggested that support for increased protected area is limited to a vocal minority of young, well-educated, elite members of society and thus have tended to discount this support. However, this study suggests that support for protected area is not confined to socioeconomic groups. Indeed, perceived risk from the forest industry was a major factor influencing support for the establishment of new protected areas and stricter regulations for industry, and this support transcends socioeconomic groups. It is rather surprising that, in a province with strong economic dependence on the forest industry and among the strictest forest management policies and procedures (i.e., the Forest Practices Code) in Canada, the public still perceives forestry as failing to protect ecological systems such as biodiversity. This should send a strong message to policymakers and the forest industry that engaging in meaningful, mutual dialogue with the public should be an integral component of managing risk associated with forestry activities. Although the current study provides some indication of public views on forest biodiversity and constitutes a form of public involvement, more inclusive public involvement processes that cultivate trust, understanding, and democratic decisions may be required to foster social acceptability of natural resource management decisions related to biodiversity conservation.[32]

Cognitions represented by value orientation had a greater effect on risk perceptions than knowledge or social-cultural factors. Contrary to expectation, social groups were not consistent predictors of risk perceptions related to biodiversity. Value orientation, however, served to amplify the effects of social-cultural influences. Social group membership had an effect on value orientation, which in turn influenced perceptions of risk. This study included an analysis of the consequences of risk perceptions of ecological systems and suggests that risk perceptions can influence other cognitive constructs such as support for natural resource policy and management. These findings suggest a need to investigate more complex models of ecological risk perception whereby risk perception is nested with a cognitive hierarchy of general attitudes toward the environment and management and policy preferences, and interactions with social-cultural variables are included.

Although this study has provided insight into perceived risks associated with forest biodiversity and its influences, it included only one dimension of ecological risk perception: a general risk domain. The literature suggests that the general risk domain is highly correlated with both perceived likelihood (or certainty) of impacts and perceived consequences of impacts of ecological risk.[2,5] These represent two distinct components of risk perception[11] that may have differing causal mechanisms. Future studies on perceived risk to biodiversity should investigate a multidimensional framework (such as certainty that impacts will occur and controllability of impacts)[3,4] and include analyses of causal mechanisms for each dimension and the influence of individual risk dimensions on policy and management preferences.

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